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Project 13. Bull Trout Studies, East Fork South Fork Salmon River

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Spatial and temporal distribution of bull trout, *Salvelinus confluentus*, in the upper East Fork South Fork Salmon River and its tributaries.

A Research Proposal

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Abstract

Columbia River bull trout (*Salvelinus confluentus*) were listed as threatened on June 19, 1998. Due to the insufficient knowledge of bull trout spatial and temporal distributions in the South Fork of the Salmon River, a recovery strategy is difficult or impossible to develop. My first objective is to assess spatial and temporal distribution of bull trout in the upper East Fork South Fork Salmon River, Idaho and its tributaries. I propose to use biotelemetry to track large fish (> 385 g)from their spawning habitats to overwintering habitats. All additional bull trout (> 100 g)will be Floy tagged and later recaptured to determine seasonal movements. My second objective is to determine bull trout distribution and abundance in the upper East Fork South Salmon River and its tributaries. I propose to snorkel all of the streams in the study area. The project will begin in June, 1999 and continue through December, 2000.

Introduction

On June 19, 1998, Columbia River bull trout (*Salvelinus confluentus*)were listed as a threatened species under the Endangered Species Act of 1973 (USFWS 1998). A variety of factors have lead to the reduced abundance of this fish, including migration barriers, irrigation diversions, non-native species competition, and environmental degradation. Once a species is listed on the Endangered Species Act, it is the Federal agencies roles to promote de-listing of the species by recovering the species. The de-listing process is typically started with attempts to learn more about the status of the listed species.

The bull trout residing in the South Fork Salmon River, Idaho (SFSR) are thought to be part of a central Idaho stronghold for the species (USFWS 1998). Within the SFSR watershed is a tributary, East Fork South Fork Salmon River (EFSFSR), that contains abundant bull trout populations (Thurow 1987; Kuzis 1997). Refer to Appendix A, Figure 1 for a map of the EFSFSR in relation to the SFSR watershed. Previous studies (Thurow 1987; Thurow and Schill 1996; Idaho Department of Fish and Game, unpublished data; Payette National Forest, unpublished data) have investigated fish populations in the EFSFSR, but many of the key questions regarding life history and ecology of these bull trout remain unanswered. Insufficient knowledge of their spatial and temporal distribution makes designation of appropriate conservation areas difficult or impossible (Stowell et al. 1996).

Currently, no information is available on life history characteristics of SFSR bull trout. This information is needed by Payette National Forest biologists for watershed analysis, restoration projects, project administration (mines, grazing allotments, prescribed fire, and recreation), and Endangered Species Act consultation. Thurow (1987) recommended that for SFSR bull trout, biologists should 1) collect data to determine age and length at maturity for fluvial fish, 2) identify principle spawning areas, 3) survey potential staging areas prior to spawning, and 4) survey for adult spawners and redds. These recommendations were made over ten years ago, and still have not been adequately addressed.

Adult fluvial bull trout have been observed only at a few locations in the SFSR. Thurow (1987) used hook-and-line, snorkeling, and electrofishing techniques in the following SFSR tributaries and found the following numbers of fish greater than 400mm total length (TL) (in parentheses) by location: EFSFSR (3), Lake Creek (4), Profile Creek (4), Tamarack Creek (2), and Sugar Creek (2). Many other tributaries (13) had bull trout in them, but no adults greater than 400mm TL were observed (Thurow 1987). While snorkeling at the mouth of Profile Creek, I have observed five bull trout exceeding 400mm TL at two different times (1993 and 1997).

Spawning areas of bull trout in the EFSFSR have not been identified. Verification of spawning habitat could lead to increased protection of these areas. Habitat utilized for redd construction is unknown for resident and migratory bull trout. Environmental factors that key spawning are not currently understood. The determination of the timing of bull trout spawning can be used by resource managers in the future to avoid sensitive areas at particular times.

Rearing habitat for juvenile bull trout is unclear. Rearing habitat can be utilized to determine trends in population through annual monitoring. Migrations of fluvial fish have not been documented in the SFSR watershed. Currently, it is not known when bull trout migrate, or even if they do. The processes related to the timing of bull trout migration are unknown. Natural resource managers can use annual migration timing information to better plan when to complete projects.

Overwintering habitat is another aspect of bull trout life history that is undetermined. Biologists can speculate on where they overwinter, but site-specific habitats have not been identified. Other populations of bull trout have shown fidelity to overwintering habitat (Swanberg 1997), so certain areas might merit increased habitat protection. Overall, many questions surround this population of bull trout.

This project will address this information gap by tracking adult bull trout from their spawning habitats to their overwintering habitats, documenting distribution patterns, identifying habitats being used, and determining fidelity to these areas. Objectives for this study are:

1. Assess spatial and temporal distribution of bull trout in the upper EFSFSR and its tributaries.
2. Determine bull trout distribution and abundance in the upper EFSFSR and its tributaries.

Bull trout life history and ecology

The historic range of bull trout was restricted to North America (Cavender 1978; Haas and McPhail 1991). Their southern most recorded location was in the McCloud River in northern California (Cavender 1978). Bull trout no longer occur in California, possibly a result of natural climatic warming and the loss of cold water habitat since the Pleistocene period. The warming was exacerbated by effects of human activities (Cavender 1978). Additionally, bull trout were historically found in Alberta, British Columbia, Idaho, western Montana, northern Nevada, Oregon, and Washington (Cavender 1978).

Bull trout have two distinct life history forms: migratory and non-migratory (resident). Migratory bull trout typically rear in tributary streams for several years before migrating to larger rivers (fluvial form), lakes (adfluvial form), or the ocean (anadromous) where they rear for several years before returning to tributaries to spawn (Shepard, et al. 1984). Resident bull trout are often restricted to headwater streams throughout their life (Thurow 1987). Both migratory and non-migratory forms are thought to exist together in some areas, but migratory fish may dominate populations where migration corridors and sub-adult rearing areas are in good condition (Rieman and McIntyre 1993).

Spawning of bull trout occurs in the fall, typically September and October (Fraley and Shepard 1989; McPhail and Murray 1979). Resident adults are believed to move relatively short distances within their natal streams to spawn. Stream temperature appears to be the primary influence on timing of spawning, but photoperiod and streamflow probably also play a role (Fraley and Shepard 1989). Spawning normally begins when water temperatures drop below 9-10 °C (Fraley and Shepard 1989). Spawning areas are characterized by gravel substrates, low compaction, and low gradient. In addition, groundwater influence and proximity to cover are also important stream characteristics influencing spawning site selection (Fraley and Shepard 1989). Hatching occurs in late winter or early spring (Weaver and White 1985). Alevins may then feed and grow within the gravel for an extended period after yolk absorption (McPhail and Murray 1979). Emergence from the gravels occurs from April through May (Shepard et al. 1984; Pratt 1992) after peak discharge (Weaver and White 1985).

Juvenile bull trout have age-specific habitat requirements. During the summer months, young-of-the-year inhabit shallow, low velocity backwater areas (Pratt 1984; Shepard et al. 1984). Bonneau and Scarnecchia (1998) found that juvenile bull trout (age 1 and older) preferred pools during summer and winter. In pools, juvenile bull trout typically reside immediately above, on, or below the substrate during summer (Pratt 1984; Shepard et al. 1984). Cobbles, woody debris, and rootwads are important cover types used during the summer and winter (Bonneau and Scarnecchia 1998). Jakober (1995) found that both beaver ponds and deep pools function as critical overwintering habitats by offering complex large woody debris in conjunction with large substrate. He suggested that movements of resident fish into overwintering habitat is first triggered by declining water temperatures, and then, if winter conditions are harsh, further movements downstream will occur by those fish occupying pool habitats that become subject to severe icing conditions.

Sexual maturity is reached in 4 to 7 years, and bull trout can live as long as 12 years (USFWS 1998). Repeat and alternate year spawning has been reported, although repeat spawning frequency and post-spawning mortality are not well known (Fraley and Shepard 1989; Pratt 1992; Rieman and McIntyre 1996; Swanberg

1997).

Growth of resident fish is generally slower than migratory fish. Resident fish also tend to be smaller at maturity and less fecund (Fraley and Shepard 1989; Goetz 1989). Resident adults range from 150 to 300mm (TL); Goetz 1989; Mullan et al. 1992. The viability of resident populations has been questioned since they may face a higher probability of extinction from deterministic, stochastic, and genetic risks (Rieman and McIntyre 1993).

Adult migratory bull trout are different from resident fish in that they migrate as juveniles (1, 2, and 3 year-old fish) to larger bodies of water (river, lake, or ocean) and rear for a number of years until sexually mature (5, 6, and 7 year-old fish) (McPhail and Murray 1979; Fraley and Shepard 1984). Once sexually mature, the migratory fish return to smaller tributary streams to spawn. Migratory adults commonly exceed 600mm TL(Shepard et al. 1984; Goetz 1989). The difference in size of resident verses migratory adults is probably due to the larger, more productive waters that migratory fish rear in.

Bull trout prey items include terrestrial and aquatic insects, macro-zooplankton, mysids, and fish (Shepard et al. 1984). Fish are common in the diet of bull trout as small as 110mm TL, and larger individuals may feed exclusively on fish (Shepard et al. 1984). Bull trout in several river basins evolved with large populations of juvenile salmon and the bull trout abundances declined with the decline of the salmon (Ratliff and Howell 1992).

Bull trout are primarily found in cold streams (Fraley and Shepard 1989). Water temperatures above 15°C are believed to limit bull trout distribution, which may partially explain the patchy distribution within many watersheds (Fraley and Shepard 1989; Rieman and McIntyre 1993). Bonneau (1994) observed that juvenile bull trout selected the coldest water available in a plunge pool, 8 to 9°C within a temperature gradient of 8 to 15°C. These cold water constraints have limited the range of many bull trout populations to only headwater regions (Rieman and McIntyre 1995).

Study Area

The study will be conducted within the South Fork Salmon River (SFSR), Idaho. The SFSR, located in west-central portion of the state, is a major tributary to the Salmon River. The SFSR watershed drains approximately 339,937 ha into the mainstem Salmon River near Mackay Bar, Idaho. Elevation ranges from 823 m at the mouth to approximately 2,827 m at North Loon Mountain. The four major watersheds of the SFSR include the Secesh River, EFSFSR, Johnson Creek, and the upper SFSR. There are also numerous smaller watersheds. Most of the study will be conducted within the upper EFSFSR watershed, but migrating adult bull trout might travel throughout the whole SFSR watershed.

The geology for the SFSR is classified as 1) volcanic, 2) metamorphoric rocks, and 3) granite. The volcanic geology is primarily found in the EFSFSR drainage and is most susceptible to mass failure processes. Metamorphoric rocks occupy a northwest-southeast trend in the eastern part of the SFSR drainage (Kuzis 1997); these rocks have the greatest impact on the landslide production in the EFSFSR and Johnson Creek drainages. The rest of SFSR is underlain by various types of granite. Chemical weathering of granite rocks breaks them down into a sandy material, so that stream channels in this lithology have high percentages of sand substrate.

Mean annual air temperature varies greatly throughout the watershed. At the Big Creek Summit monitoring site (elevation 2,005 m), average daily maximum temperature is 17°C, minimum is -10°C, and the mean is 3°C. At Yellow Pine (elevation 1,545 m), average daily maximum is 12.6°C, minimum is -4.7°C and the mean is 3.9°C. Frost can occur any day of the year at elevations greater than 2133 m.

Precipitation averages about 79 cm per year, falling mostly as snow. Mean annual precipitation increases with elevation and ranges from about 46 cm at lower elevations, 70.1 cm at Yellow Pine, 124 cm at Big Creek Summit, and 148.1 cm at Deadwood

Summit. Heaviest precipitation usually falls in November and December from maritime low pressure systems. Occasionally, subtropical Pacific storms move over the area producing warm rainstorms in late fall or early winter. These storms have caused significant rain-on-snow flood events such as in December 1964. During the summer, the Pacific high moves into western Idaho, producing sporadic thunderstorms with localized brief high-intensity rainfall.

Upland vegetation consists of several cover types. Lower elevation areas support mixed conifers including Ponderosa pines (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga menziesii*). Mid- and higher elevations areas support lodgepole pine (*Pinus contorta*), grand fir (*Abies grandis*), Englemann spruce (*Picea engelmannii*), and subalpine fir (*A. lasiocarpa*). Slopes are characteristically steep, and high elevation areas are marked by craggy peaks, cirque basins, and other evidence of glacial activity. Much of the lower elevation areas within the basins are open grassland with scattered trees on steep slopes, especially on the southern aspects.

Riparian stream bank vegetation typically consists of grasses, forbs, willow (*Salix spp.*), and alder (*Alnus spp.*). Mid-stories are composed of shrub, typically spirea (*Spiraea spp.*), huckleberry (*Vaccinium spp.*), and alder. Riparian over-story includes lodgepole pine and Douglas fir. Open meadows have over-story vegetation of grasses and sedges mixed with willow and alder.

Peak stream discharge occurs during a six-week period in May and June following snowmelt. Base flows occur from September through January. For the period 1928 - 1995 at the mouth of Johnson Creek near Yellow Pine, mean annual discharge ranged from 3 m^3/s to 18 m^3/s, with a peak discharge of 179 m^3/s in 1974 (USGS 1996).

The SFSR and its tributaries generally have low nutrient and mineral concentrations. Data collected from 1979 to 1981 on the upper SFSR measured average total dissolved solids (TDS) was at 48 mg/l, average alkalinity 24 mg/l, and specific conductance 56 μmhos/cm (Thurow 1987).

The upper EFSFSR watershed consists of approximately 33,994 ha and enters the EFSFSR near the confluence of the Johnson Creek (Table 1; Appendix B). The river flows through a v-shaped canyon with short stretches of low gradient channel. Most of stream channel is high gradient. Discharge measurements range from peak flows of 40 - 85 m^3/s during peak flows in late May or early June to about 8 m^3/s or less in September (Kuzis 1997).

Table 1. Upper EFSFSR watersheds by hectares and relative percentage.

Watershed	Hectares	Percent of land of upper EFSFSR
No Mans/Boulder	3,714	11
Profile Creek	5,030	15
Quartz Creek	4,972	14
Sugar Creek	4,660	14
Salt and Pepper	4,278	13
Tamarack Creek	4,751	14
Upper East Fork	6,473	19
Total Watershed	33,878	100

The primary land owner in the upper EFSFSR watershed is the U.S. Forest Service. Other land owners include private and state entities. A road system parallels many of the tributaries in the upper EFSFSR. A large gold mine (Stibnite Mine) near the headwaters of the EFSFSR closed in late 1997. Rehabilitation including revegetation, stream channel re-contouring, and removal of mining debris began in 1998. Other land uses in the watershed include recreation, small mineral developments (less than 2 ha), and road maintenance.

The upper EFSFSR is home to many native fish including summer chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*O. mykiss*), redband trout (*O. mykiss*), bull trout, westslope cutthroat trout (*O. clarki lewisi*), mountain whitefish (*Prosopium williamsoni*), bridgelip sucker (*Catostomus columbianus*), and sculpin (*Cottus spp.*)(Kuzis 1997; Simpson and Wallace 1982). Introduced species and stocks include mixed cutthroat trout stocks (*O. clarki spp.*), kamloops rainbow trout (*O. mykiss*), brook trout (*Salvelinus fontinalis*), cutthroat x rainbow hybrids, golden trout (*Salmo aquabonita*), and arctic grayling (*Thymallus arcticus*) (Kuzis 1997). There have been 13 different fish population and habitat assessments completed by the U.S. Forest Service and Idaho Department of Fish and Game on the upper EFSFSR and its tributaries between 1979 and 1996 (Kuzis 1997).

In the EFSFSR, fishery biologists have snorkeled two sites primarily to monitor anadromous populations. While conducting general parr monitoring, bull trout densities were also recorded. Thurow (1987) established one site in the upper EFSFSR (1.5 km upstream of Tamarack Creek) in 1984. The site was snorkeled in 1984 (summer) by Thurow (1987); bull trout density was 1.43 m^2. Continuing in 1986, Kim Apperson (Idaho Department of Fish and Game, personal communication) snorkeled this site to determine density of juvenile steelhead and chinook salmon present. The monitoring has continued annually through 1998. In 1994, an additional snorkel site was added to the annual monitoring to better reflect areas used by juvenile chinook salmon. The site is located on the EFSFSR at the mouth of Sugar Creek. Data summaries have been completed for both monitoring sites and are summarized in Table 2.

Table 2. IDFG General Parr Monitoring, EFSFSR site (1986-1998). Density of bull trout (BT) in number fish / 100m^2.

Year	BT(0-5cm)	BT (5-13cm)	BT (>13cm)
1984 a	1.43		
1985 a	nr	nr	nr
1986 b	0.0	0.0	0.0
1987 b	0.0	0.0	0.5
1988 b	0.0	0.0	0.0
1989 b	0.0	0.0	0.2
1990 b	0.0	0.0	0.2
1991 b	NA	NA	NA
1992 b	0.0	0.0	0.0
1993 b	0.0	0.0	0.0
1994 b	0.4	0.0	0.4
1995 b	0.0	0.0	0.0
1996 b	0.0	0.0	0.4

a) EFSFSR, 1.5 km upstream of Tamarack Creek confluence.
b) EFSFSR, 0.9 km upstream of Tamarack Creek confluence.

Additionally in 1994, twenty-five sites were snorkeled to determine species densities over a larger area. All sites were permanently recorded with detailed field maps and photos and some were recorded with Global Positioning System (GPS) coordinates. Densities of bull trout from these additional twenty-five sites snorkeled in 1994 are located in Table 3.

Table 3. Summary of bull trout (BT) densities (number of fish / $100m^2$) from 1994 IDFG snorkel survey.

Sample Sites	0-5cm	5-13cm	13-20cm	>20cm
EFSFSR, 0.1 above Johnson Cr	0.00	0.00	0.34	0.17
EFSFSR, below Quartz Cr	0.00	0.00	0.14	0.14
EFSFSR at Quartz Cr confluence	0.00	0.00	0.00	0.00
EFSFSR, 0.1 above Quartz Cr	0.00	0.00	0.00	0.17
EFSFSR, below Double A Cr	0.00	0.00	0.00	0.00
EFSFSR at No Man's Cr conflu.	0.00	0.00	0.21	0.21
EFSFSR at Profile Cr confluence	0.00	0.00	0.00	0.26
EFSFSR, 2.1 below Tamarack Cr	0.00	0.00	0.00	0.00
EFSFSR, 0.5 below Tamarack Cr	0.00	0.00	0.11	0.00
EFSFSR, above Johnson, Tamarack	0.38	0.00	0.00	0.38
EFSFSR, 0.5 below Salt Cr	0.00	0.00	0.18	0.00
EFSFSR at Salt Cr confluence	0.00	0.00	0.26	0.00
EFSFSR, 0.6 below Sugar Cr	0.00	0.00	0.00	0.00
EFSFSR, 0.2 below Sugar Cr	0.00	0.00	0.53	0.00
EFSFSR at Sugar Cr confluence	0.00	0.00	0.00	0.64
Sugar Creek	0.00	0.00	0.62	0.00
Sugar Creek, bridge	0.00	0.00	0.00	0.00
Profile Cr, 0.5 above Missouri	0.00	2.28	1.37	0.46
Profile Cr at mouth Missouri Cr	0.00	0.55	1.10	0.00
Profile Cr, 3 mile US mouth	0.00	3.00	1.25	0.00
Profile Cr, 2 mile US mouth	0.00	1.32	0.99	0.33
Profile Cr, 1 mile US mouth	0.00	0.89	0.44	0.00

Profile Cr, 0.5 mile US mouth	0.00	0.73	0.00	0.00
Tamarack Cr, 0.5 mile US mouth	0.24	0.24	0.48	0.00
Tamarack Cr at mouth	0.00	0.00	0.00	0.00

Stream temperature in the upper EFSFSR and selected tributaries have been monitored over the period 1992 to 1998. Maximum stream temperatures by location in 1997 and 1998 varied, but were less than 18°C (Table 4).

Table 4. Stream temperature data (°C) from summer 1997 and summer 1998 in the upper EFSFSR watershed.

Stream	1997	1998
EFSFSR (below Sugar Cr)	13.5 (8/9)	N/A
Profile (mouth)	12.0 (Aug)	14.0 (Aug)
Tamarack (mouth)	16.8 (Aug)	16.4 (Aug)
Sugar (mouth)	14.0 (8/9)	N/A
Garnet (mouth)	11.0 (Aug)	11.6 (Aug)
Meadow (mouth)	16.3 (Aug)	17.8 (Aug)
Blowout (mouth)	17.1 (Sept)	15.9 (Aug)

Overall, high water temperatures in the upper EFSFSR and its tributaries are not thought to limit bull trout populations. The stream temperatures of this area provide adequate spawning temperatures in September (average temperatures are less than 9°C).

Materials / Methods

For Objective 1: Assess spatial and temporal distribution of bull trout in the upper EFSFSR and its tributaries.

For future identification and information purposes, each bull trout captured will be Passive Integrated Transducer (PIT) tagged, adipose fin clipped, and FLOY® tagged. The PIT tag will allow quick identification of individual fish on subsequent capturing. Idaho Department of Fish and Game has been placing PIT tags in all bull trout that they capture and have requested that we tag the fish (K. Apperson, Idaho Department of Fish and Game, McCall, personal communication). Floy® tags will allow snorkelers to identify tagged fish in the future, and will facilitate visual identification of tagged spawning adults from the stream bank. The adipose clip will be used to assess tag loss of both PIT and Floy tags concurrently.

A total of thirty-six large bull trout (twenty-five with a minimum weight of 530 g and eleven with a minimum weight of 385 g) will be surgically implanted with radio tags. The thirty-six fish will provide us with an adequate sample size. Previous studies (J. Brostrom, Idaho Department of Fish and Game, Lewiston, personal communication) have incurred up to 50 percent mortality, in the worst case, of radio-tagged fish; other studies (B. Bellerud, Oregon Department of Fish and Wildlife, LaGrande, personal communication) have shown lower mortality. The exact cause of mortality in those other studies is unknown. For this reason, great care will be taken to minimize stress on fish. These procedures will be assumed not to effect the fish's behavior (e.g. growth, feeding, spawning, and swimming ability).

Practice surgery will be conducted on brood stock rainbow trout prior to the field season. See Appendix B for the outline of the time schedule of completing various steps of the project. Equipment needed for a radio telemetry project is located in Appendix C.

Radio Transmitter Selection

Two Lotek SRX400 receivers will be used for this study, one as a fixed station and the other a remote station. Coded transmitters will allow individual identification of fish when tracking, while using only three frequencies.

Bull trout will be tracked for approximately 550 days (July 1999 - December 2000). The adult fluvial fish we plan to tag are approximately 400mm TL and greater. The associated weight for these lengths range from 680g to 930g using information provided by J. Brostrom (Idaho Department of Fish and Game, Lewiston, personal communication). Winter (1996) suggests tag weight to not exceed 2 percent of the sampled fishes body weight. I will purchase 25 MCFT-3FM transmitters for the 1999 field season. The transmitters weigh 10.3 g each and are 11mm x 59mm in size. Provisional on future funding, additional tags will be purchased for the 2000 field season.

The University of Idaho will be providing an additional eleven transmitters (Lotek MCFT-3BM) for this project. These transmitters are smaller (7.7 g) than the ones we are ordering, and will allow us to tag smaller adults. The typical life for the MCFT-3BM is 238 days. The reduced life of these transmitters will only allow a single spawning and overwintering season to be tracked.

Capture

The capturing of bull trout in the upper EFSFSR will be the most challenging aspect of this study. One method of capturing fish could be an in-stream weir, but it would be difficult to maintain in rivers such as the EFSFSR due to the unpredictability of high water events. In addition, many hours of time would be needed to maintain a weir.

Due to the above mentioned problems associated with weirs, I will primarily attempt to capture bull trout in deep pools prior to spawning using spinning rod and reel with 5 kg test line and artificial lures with treble hooks. This method has proven effective in previous studies in other locations (B, Bellerud, Oregon Department of Fish and Wildlife, LaGrande, personal communication; J. Burrows, British Columbia Ministry of the Environment, Fort St. John, personal communication). The mouths of Quartz, Profile, Tamarack, and Sugar Creeks and deep pools in the upper EFSFSR will be initially sampled to collect the adult bull trout. If we are not successful in capturing all the samples in the upper EFSFSR, our study site will be expanded to include the lower EFSFSR.

Angling methodology will use heavy test line to minimize retrieval time after hooking. Angling equipment will include artificial lures, bait with circle hooks, and artificial flies. Secondary methods of capture will include beach seines with attached bag, passes with a gill net, and pre-snorkeling assisted electrofishing. Secondary methods will only be used if angling is uneffective.

Samplers will be dispersed while attempting to catch bull trout. Jim Bacon, a local angler who historically caught bull trout in the upper EFSFSR, will assist in capturing our samples. Once a fish is captured, it will be placed in a stream tube. The stream tube is a PVC pipe(90 cm by 15 cm or 90 cm by 10 cm, depending on the size of the captured fish) with holes (2 cm in diameter). The two sizes of stream tubes will allow the holding a large bull trout (>3000 g) or smaller bull trout (385 g - 3000 g). The inside of the PVC pipe is black to help calm the fish. One end of the tube has a sliding piece of plexiglass that acts as a door and the other end has a sealed cap. The stream tube will be tied to an object on the stream bank and placed in the stream. Samplers will immediately inform the surgery crew when a fish is caught by two-way radio. The surgery crew will rapidly move to the capture site to implant the transmitter. If weather conditions are warm when a fish is captured, surgeries will be delayed until the evening hours.

Surgery

The surgery crew will consist of two individuals; one to do the surgery and one to assist. The equipment needed for surgery is listed in Appendix C. The surgery station is portable, and will be transported to each capture site. The surgery station consists of a cooler, re-circulation pump and tube with shut-off valve, padding, v-shaped holder, surgical instruments, and other related surgical supplies.

All surgical instruments and surfaces which might contact the fish will be cleaned with a general iodophor solution (Argentyne) and rinsed with clean water. The radio tag, PIT tag, and Floy® tag to be used will also be cleaned and sterilized in this manner. Latex surgical gloves will be worn by the person performing the surgery to reduce the likelihood of spreading a disease from fish to fish. To keep track of an individual fish's information, a data sheet will be used. Before surgery, each radio tag will be checked for operation using the receiver.

Once a bull trout has been captured and is ready for surgery, I will transport it from the stream tube and place it into a cooler that contains a 60-80 mg/l MS-222 solution.

Anaesthetizing of the bull trout should occur in 2-3 minutes. Once anaesthetized, the fish will be measured (total length in mm), weighed (g), PIT tagged, FLOY tagged, and fin clipped (genetic testing). The fish will then be transferred to the padded v-shaped holder and placed on its dorsum. MS-222 solution will be continuously pumped over its gills and head to maintain anesthesia throughout the surgery.

Bentadyne is applied to the fish with a sterile gauze pad in the location of the incision and the anticipated antenna exit hole. A 4-cm incision will be made approximately 3 cm from the mid-ventral line and anterior to the pelvic fins with a scalpel and scalpel guide (Appendix D, Figures 1 and 2). Care will be taken to not puncture the swim bladder or kidney with the scalpel.

After the incision is made, a grooved receiver is placed posteriorly through the incision. The end of the receiver will be posterior of the pelvic fins. A 14 gauge needle (10 cm in length) is then pushed through the skin onto the grooved receiver and then pushed anteriorly to the incision (Appendix D, Figures 3 and 4). Still holding the grooved receiver, the transmitter antenna is slid through the needle till it extrudes (Appendix D, Figures 5 and 6). The grooved receiver is removed from the incision and the radio tag is then placed into the body cavity. Suturing will consist of three surgeon's knots (Appendix D, Figures 7 - 10). The knots will be tied snugly. Bentadyne will be applied to the sutured area and antenna exit hole.

Recovery / Release

After transmitter implantation, the fish will be moved back to the stream tube to recover. Each fish will be held there for five minutes or until the fish has recovered, during which time the radio transmitter will be tested again. Fish will be released near the site of capture. Total time from capture to release will be approximately 15 minutes.

Tracking

Following the migrations of the adult bull trout will be accomplished by fixed and mobile tracking. The fixed station will be placed on the South Fork Salmon River (0.8 km downstream of the Secesh River confluence). A four element yagi directional antenna will be used at the fixed site. A data logger will record each fish that passes. Downloading of the fixed data logger onto a laptop personal computer will occur weekly from June to October and monthly from November to May. Further refinement of downloading of data will take place once migration times are determined. Fish have been effectively tracked from a fixed site at this location for the past eight years (Pat Keniry, University of Idaho, Moscow, personal communication).

Mobile tracking will be used to precisely determine locations of tagged fish. Tracking will be pursued primarily by truck, but also by boat, airplane and on foot. Triangulation is used to determine specific locations of individual tagged fish. The sites will be recorded using GPS, or when GPS is not available, on topographic maps using prominent land features.

Mobile tracking will be conducted weekly from June through September, and monthly from October through May. A random sub-sample of the tagged fish will be tracked a continuous 18 hour period to determine diel movements for individual fish. If an individual fish is not located by truck, tracking by foot will be conducted. If a fish is still not located, aircraft tracking, which is expensive, will be conducted as a last resort. If tagged fish are all located in stream sections near roads, tracking will be completed in two days or less. Once the tagged fish move into tributaries not bordered by roads, tracking will take longer.

Habitat data will be not be collected at each tracked fish's location, due to the combination of tracking methods. Aerial tracking will not allow specific microhabitat quantification. Depending on the first season's results, habitat parameters could be sampled in the future.

Temperature data loggers will be installed at the following locations: Quartz Creek (mouth and 3km upstream), Sugar Creek (mouth and 3 km upstream), Profile Creek (mouth and 3 km upstream), Tamarack Creek (mouth and 3 km upstream of mouth), EFSFSR (1 km upstream of mouth, confluence of Johnson Creek, and 1 km upstream of Sugar Creek confluence), SFSR (South Fork Guard Station Bridge, 3 km downstream of Secesh River (fixed receiver site)). Other sites will be added depending on where spawning, rearing, and overwintering sites are located through radio telemetry.

Discharge data will be obtained from the following three stream gauges: Johnson Creek at Yellow Pine, SFSR at Krassel, and Salmon River at Whitebird. These three sites should provide adequate information regarding flow conditions in the EFSFSR.

Data Analysis

The data obtained from the telemetry study will be coordinate locations for each individual fish. It is important to note, each individual fish is an experimental unit, not each recording of their location (Winter 1996). The fish's locations that have GPS points will have latitude, longitude, and elevation. Other non-GPS locations are not as accurate, but will still allow mapping of their coordinates.

Nonparametric testing uses the sample median, instead of the sample mean. Movements of bull trout will be categorized into three categories: "up", "stay", and "down". Foster and Clugston (1997) used this method to investigate seasonal migration of gulf sturgeon (*Acipenser oxyrinchus desotoi*). "Up" will indicate an upstream movement (> 1 km) between tracking intervals. "Stay" will be used for individuals where little movement (≤ 1 km) is observed between tracking intervals. "Down" will refer to individuals that move downstream (> 1 km) between tracking intervals. Bull trout that are observed in the "stay" category are thought to be residents, while migratory bull trout will be either "up" or "down".

A nonparametric runs test for randomness (Brockett 1984) will be used to determine if individual fish movements are random or not. To use the sign test, I will determine the proportions of the "up" and "down" signs. The following hypothesis will be tested:

H_o: the sequence of "up" (+) and "down" (-) signs are random.

H_a: the sequence is not random

The following equations will be used to test the hypothesis:

$$\mu_U = \frac{2n_1n_2}{n_1+n_2} + 1 \qquad \sigma^2_U = \frac{2n_1n_2(2n_1n_2-n_1-n_2)}{(n_1+n_2)^2(n_1+n_2-1)}$$

Where n_1 = number of + signs and n_2 the number of - signs. Let μ equal the total number of runs among the n_1 + n_2 observations.

To test H_o, I will calculate

$$z = \frac{u-\mu_U \pm ½}{\sigma_U}$$

where the continuity correction ½ is subtracted when u is greater than μ_U and is added otherwise. I will reject H_o if $z < -z_{\alpha/2}$ or $z > z_{\alpha/2}$.

The same test will be used to determine if the group of fish moved in a similar fashion. Values of -, 0, and + will be used for down, stay, and up, respectively.

The following hypothesis will be tested:

H_o : Fish are stationary (residents), greater proportion of fish are have the 0 sign.

H_a : Fish are not stationary, proportion of + and - is greater than 0.

where mean is the median directional movement for the group. A χ-square test will be used to test the H_o. If H_o is rejected, then a greater proportion of the tagged fish are migratory. If H_o fails to be rejected, then a greater proportion of the fish are stationary.

The effects of discharge and seven-day moving average on fish movement rates will be investigated by using the following multiple linear regression model:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1 X_2 + \varepsilon$$

where Y is the mean movement rate, X_1 is the average discharge, X_2 is the seven-day moving average stream temperature, and ε is the residual error term. β_3 describes the interaction effects between average discharge and seven-day moving average stream temperature. Significant interaction effects on the regression analysis will be tested by the following hypothesis:

H_o: $\beta_3=0$

H_a: $\beta_3\neq0$

If H_0 is rejected, then effects of discharge and seven-day moving average on fish movement rates are dependent on the interaction of β_1 and β_2. If H_o fails to be rejected, then the effects of discharge and seven-day moving average on fish movement is not dependent on the interaction, and the following hypothesis will be tested to determine the significance of discharge and seven-day moving average:

H_o: $\beta_i = 0$ for $_i = 1$ or 2

H_a: $\beta\neq0$

Significant positive estimates will indicate movement rate increases as the independent parameter increases. Conversely, significant negative estimates will indicate movement rate decreases as the parameter increases.

Other hypothesis tests regarding movement will be investigated after preliminary review of the first season's data. Graphical displays of spatial data for each fish will be graphed and analyzed for similarities or differences.

Materials / Methods

For Objective 2: Determine bull trout distribution and abundance in the upper EFSFSR and its tributaries. Objective 2 will be investigated only if time allows during the field season or if no large bull trout (> 385 g) were captured in Objective 1.

Bull trout distribution and abundance will be determined using snorkeling techniques. Snorkeling will be conducted starting at the mouth of a tributary and sampling upstream. The upper EFSFSR and its tributaries will be snorkeled and densities (number of fish / m^2) of bull trout will be determined. Habitat type (pool, riffle, run, or glide) will be classified by a bank observer using a ten step method (T. Bjornn, University of Idaho, Moscow, personal communication). As the snorkeler proceeds upstream snorkeling, the bank observer will follow closely behind and record individual fish counts from each habitat type. When a bull trout is encountered, the bank observer will attempt to capture the fish using hook and line. All bull trout captured will be Floy tagged for additional bull trout movement information associated with objective number one.

Snorkeling will primarily be conducted in daylight hours. Thurow and Schill (1996) found no significant difference in day-time and night-time snorkeling in enumerating fish populations in Profile Creek (a tributary to the EFSFSR). Other studies have found a significant difference between day-time and night-time snorkeling (Bonneau 1994; Jakober 1995). Thurow and Schill (1996) discussed the possibility of temperature having an effect on the bull trout's behavior, and subsequently the ability to observe bull trout. Thurow and Schill (1996) conducted their counts in water temperatures from 9 - 13.5°C, while the other studies (Bonneau 1994; Jakober 1995) were predominantly in colder environments (0 - 12°C). In a test at water temperatures from 11 to 12°C, Bonneau et al. (1995) reported that day and night counts were not significantly different. Furthermore, Jakober (1995) reported diel differences in observed densities of bull trout in Montana as water temperatures declined below 7°C; densities observed at night in winter were 5 - 10 times larger than densities observed during the day. Thus, if stream temperatures are below 9°C when day-time snorkeling, additional night-time snorkeling will be used to test for differences in the density estimates.

Snorkeling will be completed when water temperature exceeds 9°C. If streams do not exceed 9°C in the summer, then that particular stream will be surveyed during the warmest portion of the day. In addition, streams less than 9°C will be night-time snorkeled (random stratified sub-sample) within 24 hours of the day-time estimate. The same techniques used during the day counts will be used at night except that the night counts will be completed with the aid of an underwater halogen light. This is similar to the technique used by Thurow and Schill (1996).

Snorkeling methodology will be similar to Thurow (1994). A list of equipment is included in Appendix C. Pre-season snorkel training will consist of species identification, enumeration, and total length estimation. Upon arriving at a snorkel site, water temperature will be measured. To begin snorkeling, the snorkeler will carefully enter the stream 5 meters downstream of the area to be snorkeled. This will reduce the likelihood of frightening the fish in an area. The snorkeler will proceed upstream, in a zigzag fashion, keeping track of the number of individual fish by species and their associated lengths. Divers will estimate fish length to the nearest 50 mm. The data will be recorded by the snorkeler on a PVC cuff. Once the snorkeling of a habitat unit is completed, the snorkeler will inform the bank observer what he/she observed.

Data Analysis

The snorkeling data will be summarized as number of fish per 100 meter^2. This is calculated with the following formula:

$$\# \text{ fish}/100\text{m}^2 = \frac{\text{number of fish observed in the habitat unit (by species)}}{\text{(average length * average width)}}$$

Previous studies (Thurow 1987; Idaho Department of Fish and Game unpublished) in the upper EFSFSR have expressed data as number fish/100m^2 format. Mean densities of bull trout will be presented for each year and a 95 percent confidence interval will be constructed. ANOVA will be used to test the following hypothesis:

H_o: Bull trout density estimates from each stream are the same from all years.

H_a: Bull trout density estimates from each stream are the not same from all years.

Fish counts in some sites may equal zero; thus, transformation of the data may be appropriate. Habitat use by bull trout in the upper EFSFSR and its tributaries. Bull trout presence in certain habitats will be compared with overall habitat availability.

Habitat use and preference of bull trout will be evaluated using Ivlev's electivity index similar to Moen, Scarnecchia, and Ramsey (1992). The following formula will be used:

$$E = (r_i - p_i)/(r_i + p_i)$$

where r_i is the proportional usage of habitat i, and p_i is the proportional abundance of habitat i (Ivlev 1961).

H_o: Bull trout randomly select habitats, no preference.

H_a: Bull trout do not randomly select habitats; they prefer certain types.

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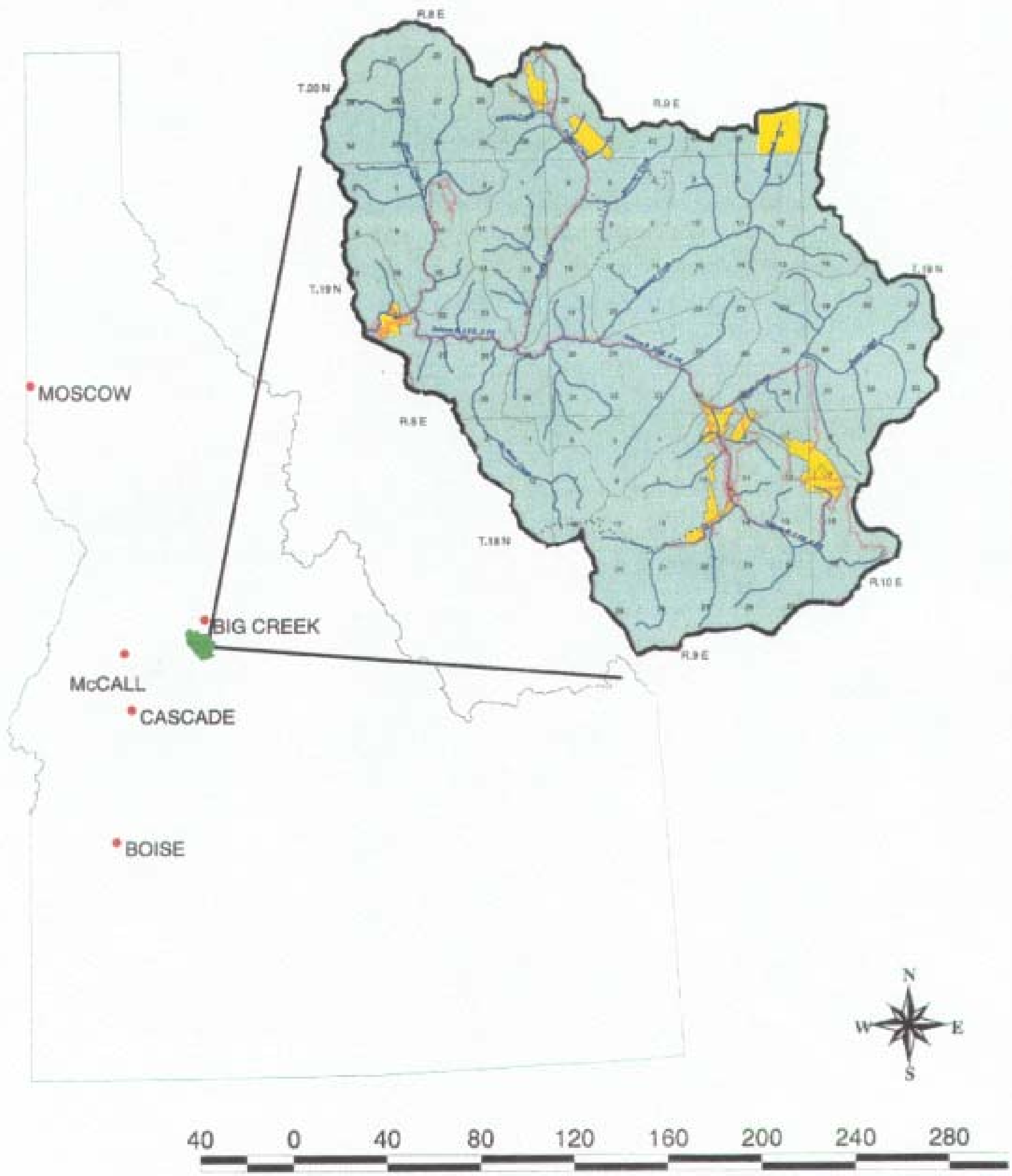
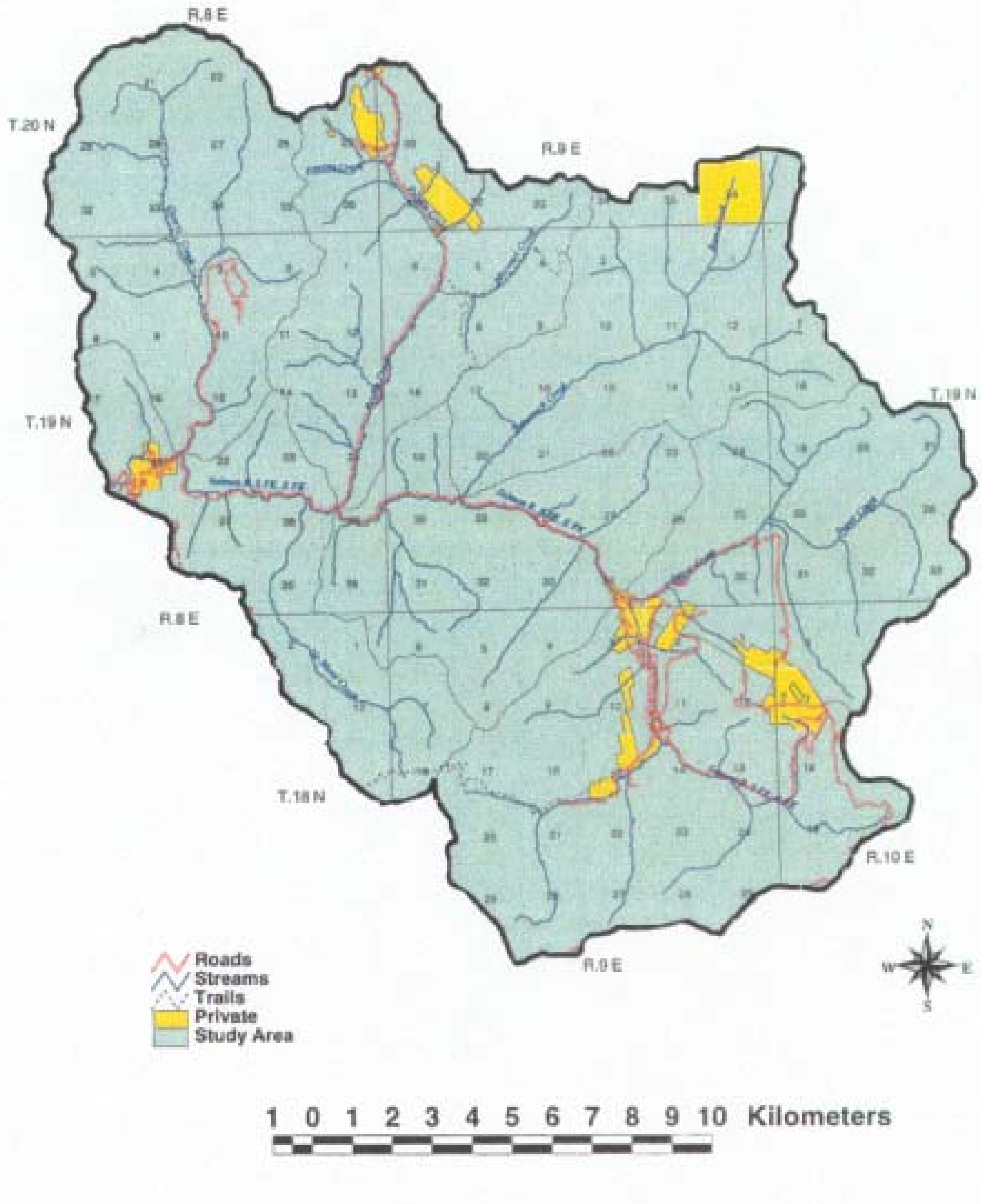
Appendix A

Map of upper EFSFSR watershed

Upper East Fork South Fork Salmon River Watershed Study Area



Upper East Fork South Fork Salmon River Watershed



Appendix B

Time Schedule

Bull Trout Study Time Schedule

Month / Year	Activity
1/99 - 5/99	Attend graduate classes at the University of Idaho. Order radio tags. Finish proposal. Practice surgery techniques on brood stock rainbow trout.
5/99	Begin field season. Investigate study site. Locate permanent snorkel transects. Determine sample reaches. Trial runs with telemetry equipment. Place stream temperature monitors at mouths of tributaries.
6/99 - 7/99	Fish for adults. Surgically implant captured adult bull trout. Perform an 18 hour tracking of an individual tagged bull trout (five random fish).
8/99	Finish radio tagging adults. One flight at end of August. Track fish from road and on foot. Snorkel tributaries to determine juvenile densities of bull trout. Attend University of Idaho part-time.
9/99	Track fish from road and on foot. Two flights to cover difficult access areas. Place stream temperature monitors at bull trout spawning sites.
10/99	Track fish from road and on foot. Two flights to cover difficult access areas.
11/99 - 12/99	One flight to determine overwintering areas.

1/00 - 5/00	Five flights to determine overwintering areas. Coordinate with IDFG and use their jet boat to track adults in Main Salmon River. Download and relaunch stream temperature monitors. Attend classes at University of Idaho full-time. Analyze data.
6/00 - 8/00	Track fish from roads. Determine juvenile densities by snorkeling in known bull trout spawning sites. One flight at end of August to better locate all tagged fish. Attend University of Idaho part-time.
9/00	Track fish from road and on foot. Two flights to cover difficult access areas.
10/00	Track fish from road and on foot. Two flights to cover difficult access areas.
11/00 - 12/00	Two flights to determine overwintering locations.
1/01 - 5/01	Finish analysis of data. Finish writing thesis and graduate.

Appendix C

Equipment List

Equipment List

The following equipment lists are organized as a checklist for performing each of the procedures (surgery, tracking, and snorkeling). Some items are listed on multiple procedures. For example, Bendix-King radio is listed on all three procedures, but only one radio is needed for the summer.

Biotelemetry Equipment

Surgery Related

- Glacier Pak® 48 qt. styrofoam cooler (2)
- Plastic fluorescent light covering (grating) standard size (4)
- Elmers® wood glue (2)
- Hacksaw blade with handle on one end (1)
- File (1)
- Duct tape (1 roll)
- Rat-tail file (1)
- High density foam rubber, 1" thick x 36" long x 36" wide (1)
- Zip ties (20)
- Bungee cord (2)
- Clear Plastic hose 1" diameter 10' (1)
- Spray nozzle with shut-off valve (2)
- Bilge pump, battery powered (2)
- Extra batteries for bilge pump, "D" size (8)
- Plastic buckets (2)
- Plastic tubs, Rubbermaid® 36"x24"x24" (2)
- Paper towels (2)
- Scale (1)
- Measuring tape or board (1)
- Small tubs for sterilizing instruments (4)
- Sharps container (5)
- Headlamps (2)
- Extra batteries for headlamps (10)
- Camera (1)
- Film, rolls 200 speed minimum (2)
- Pocket thermometer (2)
- Pencil (2)
- Data sheets (20)
- Maps (1)
- GPS unit (1)
- Extra batteries for GPS unit (10)

Bendix-King radio (1)
Tackle box (1)
Spinning rod and reel (2)
Spoons (8)
5 kg test line 300 m (1)
Turkey baster (1)
MS-222 100g bottle
Receiver (1)
Transmitters (36)
Floy® tags (36)
PIT tags (36)
Containers for genetic samples (36)
Floy tag® installing tool (1)
PIT tag reader (1)
Betadyne 3.785 l bottle (1)
Scalpel handle (2)
Scalpel blades (50)
Tissue forceps (2)
Needle holder with scissors (2)
3/0 suture, reverse cutting needle - ½ circle size 10 45cm (40)
14 gauge needle 10cm (5)
Utility scissors (1)
Sterile gauze pads (100)

Tracking Related

Lotek SRX400 receiver (2)
Lotek MCFT-3BM transmitter (11)
Lotek MCFT-3FM transmitter (25)
Three element yagi directional antenna (2)
Automobile antenna mounting kit (1)
Lotek Data logger for fixed site (1)
Topographic maps
GPS unit (1)
Extra batteries for GPS unit (10)
Bendix-King radio (1)

Snorkeling

Dry suit (2)
Mask (2)
Hood (2)
Wading boots (2 pair)
50 m measuring tape (1)
1.5 m depth stick (1)
PVC tatum (2)
Pencil (2)
Data sheets (20)
Waterproof halogen flashlight (2)
Extra batteries for flashlights (10)
Bendix-King radio (1)

Appendix D

Surgery Photos

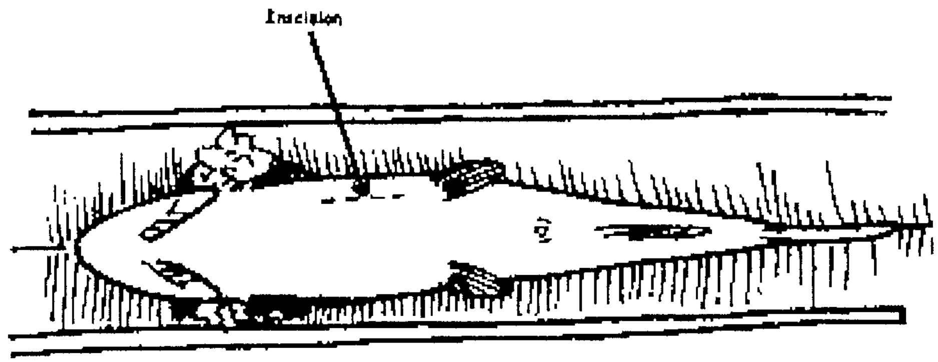


Figure 1. Incision location. Provided by B. Bellerud, Oregon Department of Fish and Wildlife, LaGrande.

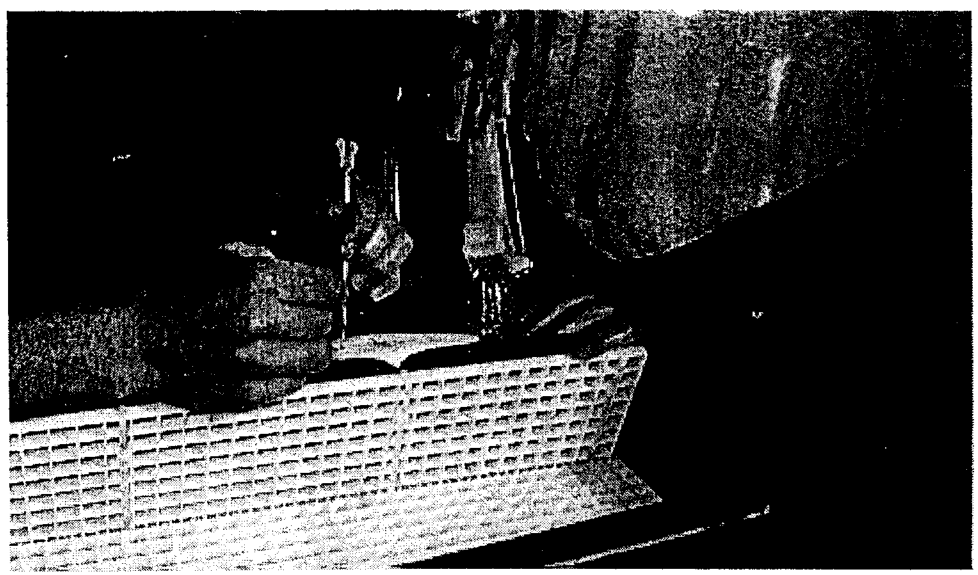


Figure 2. Making the incision.

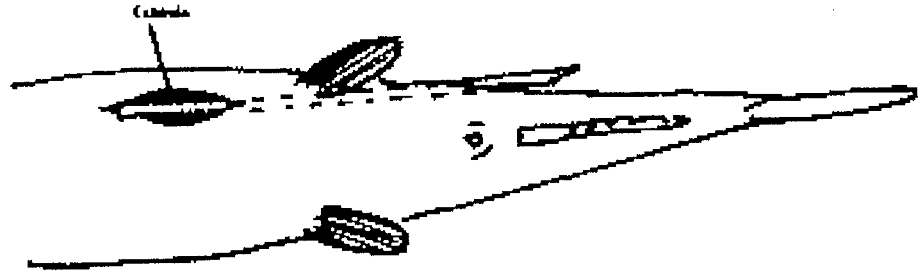


Figure 3. Placement of cannula. Antenna is placed into cannula and out through the side of the fish. Provided by B. Bellerud, Oregon Department of Fish and Wildlife, LaGrande.

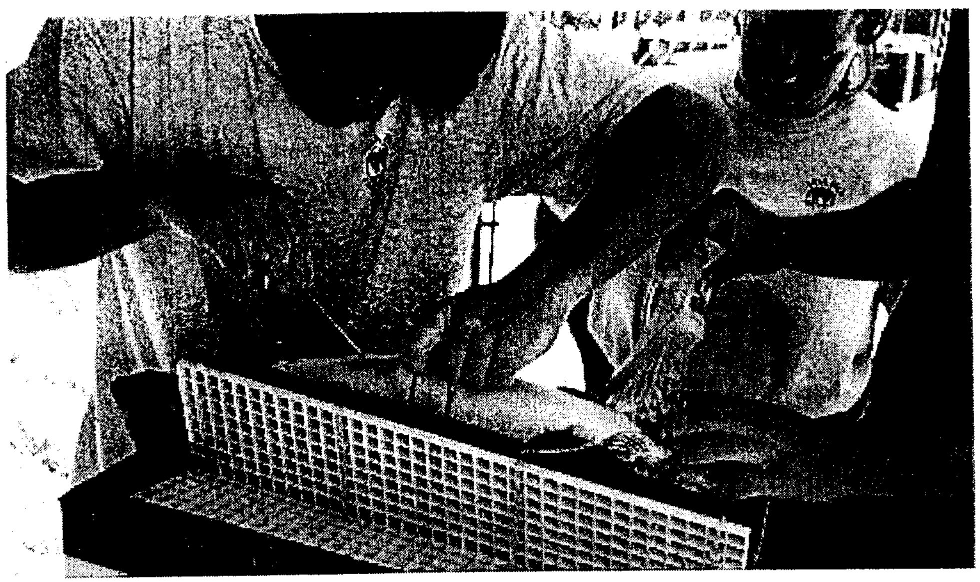


Figure 4. Cannula coming out of the fish.

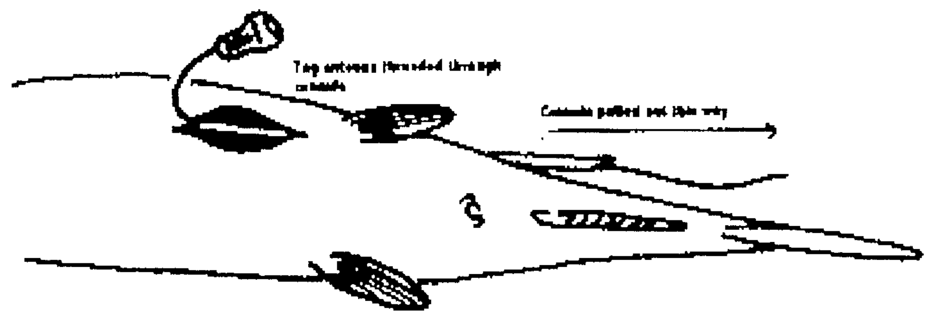


Figure 5. Placement of radio antenna through the cannula and out the side of the fish. Provided by B. Bellerud, Oregon Department of Fish and Wildlife, LaGrande.

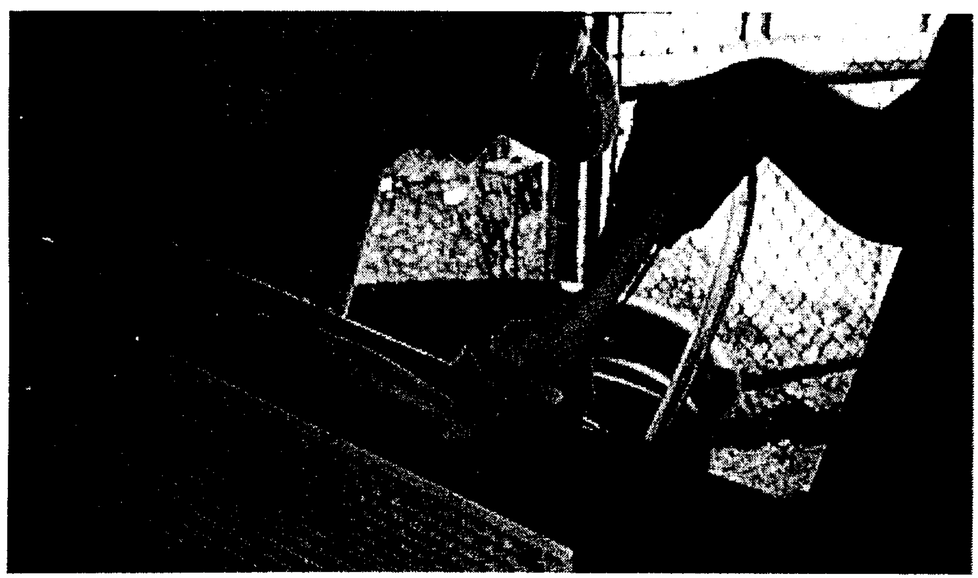


Figure 6. Radio tag is being inserted into body cavity.

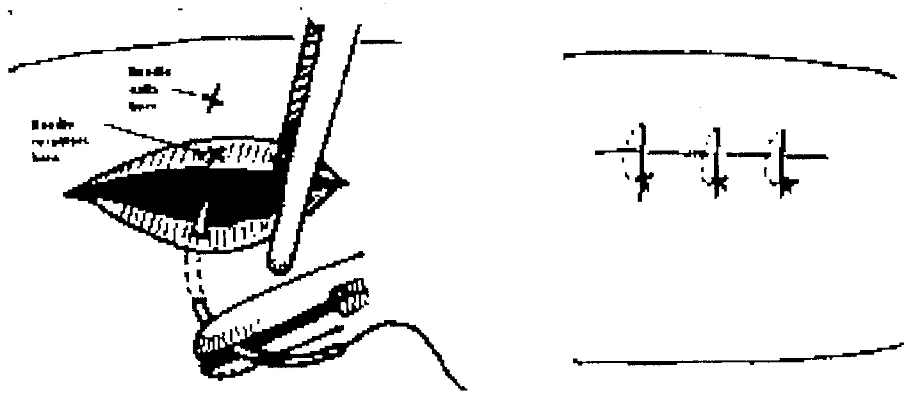


Figure 7. Suturing of the tissue. Provided by B. Bellerud, Oregon Department of Fish and Wildlife, LaGrande.

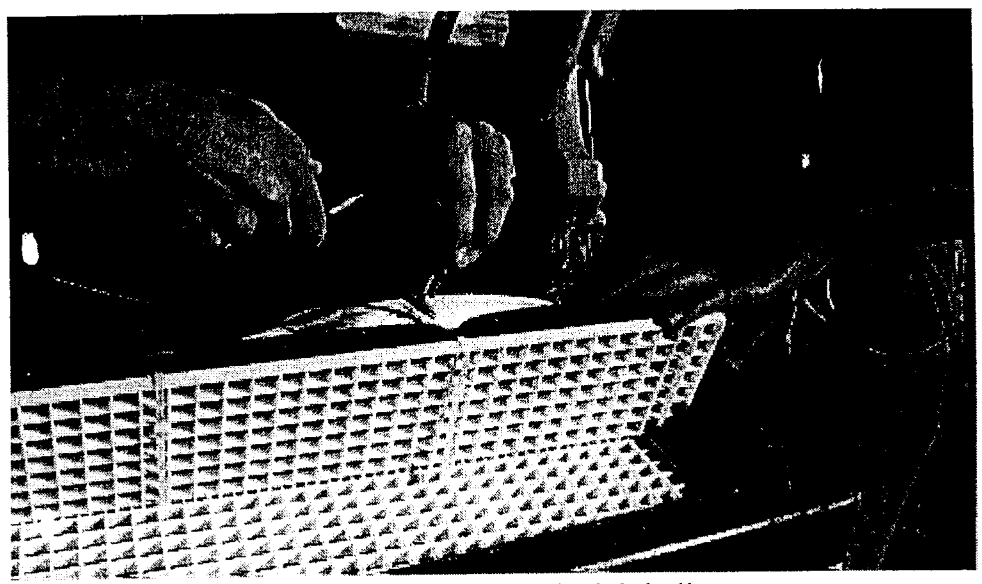


Figure 8. Actual suturing of an implanted adult bull trout.

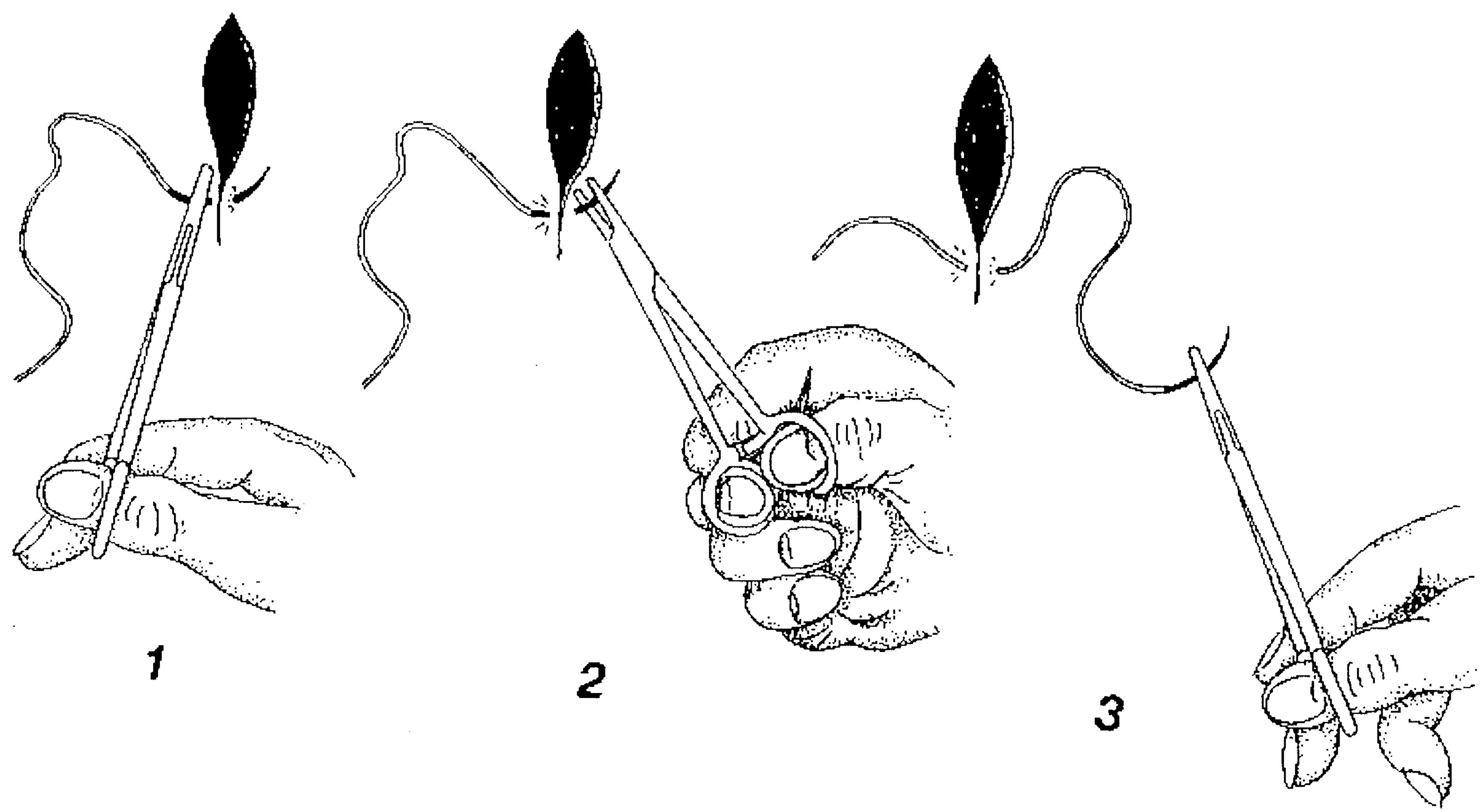


Figure 9. Suturing procedures. Provided by J. Burrows, British Columbia Ministry of the Environment, Fort St. John.

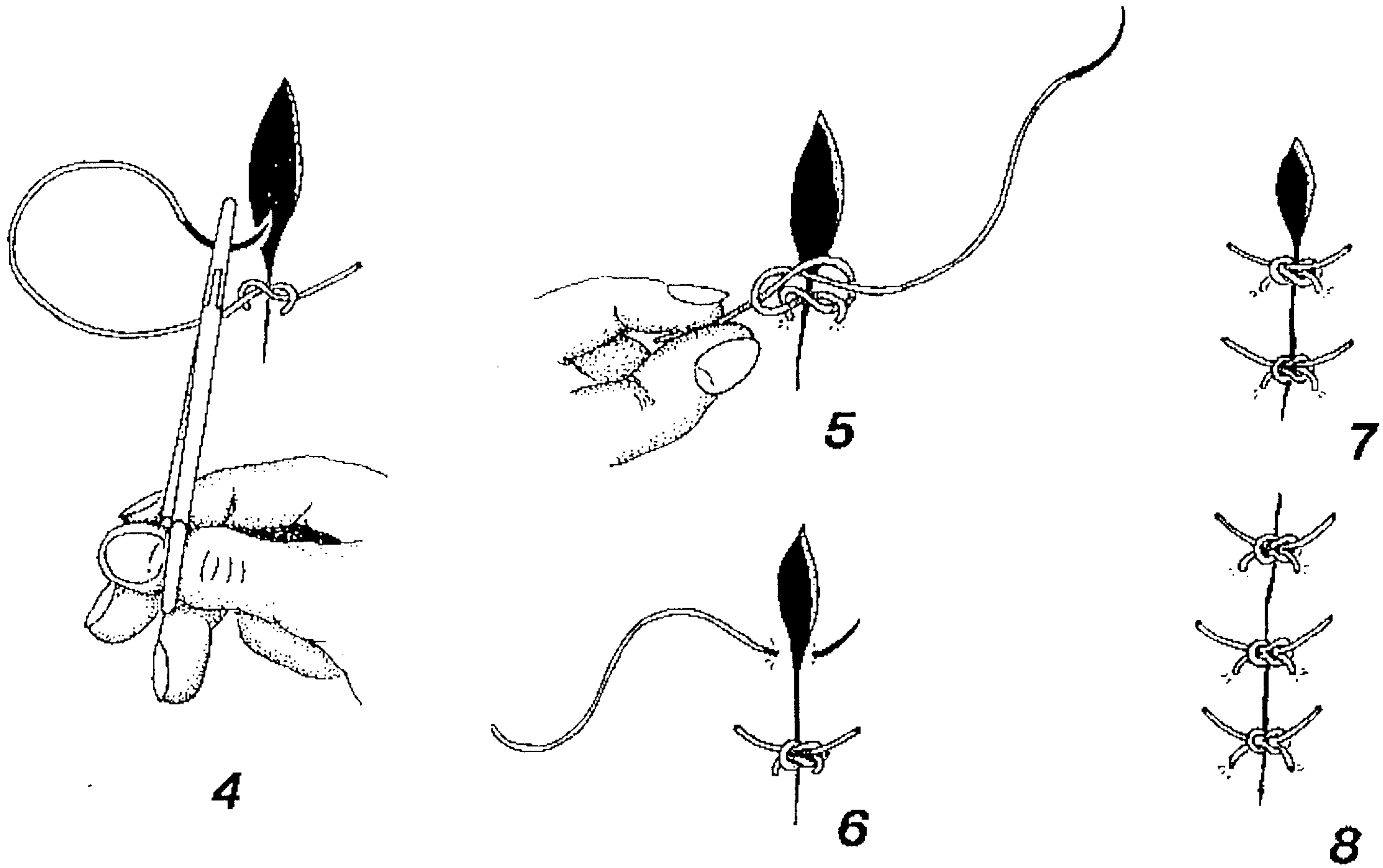


Figure 10. Suturing procedures continued. Provided by J. Burrows, British Columbia Ministry of the Environment, Fort St. John.